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(54) BATTERY AND EQUIPMENT OR DEVICE HAVING THE BATTERY AS PART OF STRUCTURE AND LOCALLY DISTRIBUTED POWER GENERATION METHOD AND POWER GENERATION DEVICE THEREFOR

(57) A battery comprising powdered active materials and capable of storing a large power, and equipment or device having the battery as parts of its structure, wherein an anode cell (2) of two vessels connected via an ion-passing separator (1) is filled with an anode powdered active material and an electrolytic solution (4), a cathode cell (3) is filled with a cathode powdered active material and an electrolytic solution (5) and conductive current collectors (6, 7) in contact with the powdered active materials are provided in the two vessels.

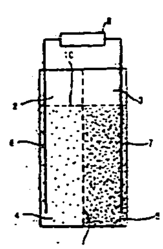

Fig. 1 (a)

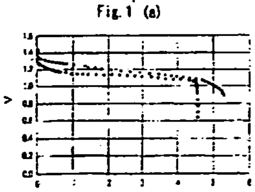

Fig. 1 (b)

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members on the anode side and the cathode side of the unit battery are made of the same material, and anode and cathode electrodes are not formed unlike the conventional battery, separating walls defining the pair of cells (unit battery) may be constituted by the conductive current collecting members. Thereby, the batteries can be connected in series structurally and electrically and the thickness thereof can be made small. As a result, the whole battery can be made compact and small-sized. In addition, since the current flows in the thickness direction, a large current flows with little resistance.

The powdered active materials function as a membrane (battery body) of the conventional battery of the membrane structure and the current flowing in the battery is directly proportional to the surface area of the active materials. The powdered materials are suspended in the electrolytic solutions and the total surface area of the total powdered materials is several thousands to several tens thousands times as large as that of the conventional battery of the membrane structure. So, the energy density is made several thousands to several ten thousands higher. Also, the powdered active materials are mixed in and suspended in the electrolytic solutions (dilute sulfuric acid for lead storage battery). When the powdered active materials are degraded, the powdered active materials together with the electrolytic solutions can be changed and the powdered active materials can be recovered. Consequently, the life of the battery can be significantly prolonged.

(2) By providing agitating means for fluidizing the powdered materials suspended in the electrolytic solutions in the respective cells to agitate the powdered materials in the electrolytic solutions, the powdered materials as electrodes are prevented from falling down due to its weight, and diffused in the electrolytic solutions. As a result, contact efficiency between powdered materials is improved and preferable contact between the powdered materials and the current collecting members or the current collectors is obtained, resulting in reduced contact resistance and an increased power. Further, width of each cell (spacing in the series direction) is increased and the capacity of the battery can be increased.

(3) By providing conductive studs integrally with and protrusively from the current collectors or the current collecting members toward the inside of the cell, the contact areas of the current collecting members and the powdered materials or the contact areas of the current collectors and the powdered materials are significantly increased and contact resistance is reduced. Therefore, the width of each cell (spacing in the series direction) can be increased and the capacity of the battery can be significantly increased.

(4) By addition of the function to stop fluidization of the powdered materials to the agitating means to reduce the amount of power supplied from the battery, the fluidization of the powdered materials can be arbitrarily stopped, resulting in a reduced amount of the power from the battery.

3. The third invention provides the following remarkable effects.

(1) It is possible to provide practical and effective use of the three-dimensional battery as part of various equipment or devices. Specifically, by adding the function of the chargeable/dischargeable power storage equipment in addition to the original function of the equipment or device, a free space is utilized to store a large power and the power storage efficiency can be greatly increased. Further, the absorbed/released heat associated with the battery reaction can be utilized for air-conditioning, or heating, cooling or the like of the materials.

(2) In the three-dimensional battery comprising two vessels provided with conductive current collectors in contact with the powdered active materials suspended in the electrolytic solutions, at least one of fluid fluidizing and dispersing means and agitating means using a liquid or a gas for fluidizing the powdered active materials in the electrolytic solutions in the two vessels may be connected to the two vessels or provided in the two vessels. Thereby, preferable contact between the powdered active materials and the current collectors is provided and contact resistance is thereby reduced, resulting in improved conductivity and increased ion diffusion speed in the electrolytic solutions. Consequently, a large current flows and a large power can be stored.

(3) Furthermore, the power stored in the three-dimensional battery is conveyed by power conveying means to be utilized as rotation power of rotary equipment, power of a mobile body, or photo energy, kinetic energy or heat energy.

4. The fourth invention provides the following remarkable effects.

(1) Without adding expensive conduction promoter such as high-purity carbon to the anode active materials and a special treatment for adding conductivity to the anode, it is possible to provide the alkali primary battery and the alkali secondary battery which have discharge voltages less likely to be reduced, have long lives, and are produced at a low cost.

(2) When the cathode active material and the anode active material are powdered, the battery structure becomes three-dimensional, the scale up results in advantages (scale up reduces a production cost), the de-

$$NiOOH + H^+ + e^- \rightarrow Ni(OH)_2$$

[0128] On the other hand, the following reaction in the anode cell 55 is conducted:

$$MHx \rightarrow M + x H^+ + xe^- \text{ (M: (powdered) hydrogen-occluding alloy)}$$

[0129] Following this, the electron (e^-) discharged from the powdered hydrogen-occluding alloy h in the anode cell 55 is collected to the current collecting member 45 forming a separating wall between the anode cell 55 and the cathode cell 54 of the right-side second unit battery 56 while moving through the powdered hydrogen-occluding alloy h, and the powdered nickel oxyhydroxide n in the cathode cell 54 of the second unit battery receives the electron (e^-) from the current collecting member 45. The electron (e^-) and the hydrogen ion are fed to the powdered nickel oxyhydroxide n to be formed into nickel hydroxide. In the anode cell 55 of the right-side second unit battery 56, the powdered hydrogen-occluding alloy h discharges the electron (e^-) and the hydrogen ion (H^+), and the hydrogen ion passes through the ion-permeable separator 43 and travels to the cathode cell 54. The electron (e^-) discharged in the anode cell 55 is collected to the anode current collector 47 and moves from the anode terminal 51, through the wiring 53, and to the load means 57, and moves to the cathode current collector 46 through the wiring 52. Thereby, a current flows from the cathode terminal 50 of the cathode current collector 46, through the load means 57, and to the anode terminal 51 of the anode current collector 47. In this way, a voltage of 1.2V × 2 (2.4V) is generated (discharge is performed).

[0130] On the other hand, the three-dimensional battery 41 is charged in the following manner. A charger 58 applies a predetermined voltage to the battery 41 to cause the electron (e^-) to be fed from the anode terminal 51 of the anode current collector 47 to the anode cell 55 of the right-side second unit battery 56. The electron (e^-) moves in the powdered hydrogen-occluding alloy h, thereby causing the following reaction to be conducted to generate a hydroxyl ion.

$$M + xH_2O + xe^- \rightarrow MHx + xOH^- \text{ (M: (powdered hydrogen-occluding alloy)}$$

[0131] The hydroxyl ion (OH^-) generated in the anode cell 55 passes through the ion-permeable separator 43 and moves into the cathode cell 54 on the left side, where it reacts with the powdered nickel hydroxide n according to the following formula and discharges the electron (e^-).

$$Ni(OH)_2 + OH^- \rightarrow NiOOH + H_2O + e^-$$

[0132] The electron (e^-) discharged in the cathode cell 54 is collected to the current collecting member 45 and moves to the powdered hydrogen-occluding alloy h in the anode cell 55 on the left side. Thereby, the reaction represented by the above formula is conducted and a hydroxyl ion is generated. The hydroxyl ion (OH^-) generated in the anode cell 55 passes through the ion-permeable separator 43 and moves into the cathode cell 54 of the first unit battery 56 on the left side, where it reacts with the powdered nickel hydroxide n according to the above formula and discharges the electron (e^-). The electron (e^-) is collected to the cathode terminal 50 of the cathode current collector 46 and sent to the charger 58.

(Second Embodiment)

[0133] Fig. 15 is a central longitudinal sectional view schematically showing a layered-type three-dimensional battery according to a second embodiment of the second invention.

[0134] As shown in Fig. 15, a three-dimensional battery 41-1 of this embodiment is a lead storage battery structured such that 6 pairs of unit lead batteries 46 are connected in series. The unit lead storage battery 56 comprises a cathode cell 54 and an anode cell 55 which are separated by an acid-resistant and ion-permeable separator 43 provided in a middle portion thereof. A leftmost wall of the cathode cell 54 of a leftmost (first pair) unit battery 56 and a rightmost wall of the anode cell 55 of a rightmost (sixth pair) unit battery 56 are respectively constituted by a side wall of acid-resistant conductor (platinous plate or lead plate) as a current collector 46 and a side wall of acid-resistant conductor (platinous plate or lead plate) as a current collector 47. A right side wall of the anode cell 55 of the unit battery 56 of the first pair and a left side wall of the cathode cell 54 of the unit battery 56 of the sixth pair are respectively constituted by side walls of acid-resistant conductors (platinous plate or lead plate) as current collecting members 45. A four pairs of unit batteries 56 situated at an intermediate position are connected in series by means of the acid-resistant conductors (platinous plate or lead plate) as the current collecting members 45 serving as separating walls defining the unit

batteries 56 in respective pairs. The leftmost (first pair) unit battery 56 and the rightmost (sixth pair) unit battery 56 are connected in series by means of the acid-resistant conductor side walls (platinous plates or lead plates) as the current collecting members 45.

[0135] In this example, each of the cells 54, 55 is filled with a dilute sulfuric acid solution (sulfuric acid aqueous solution) r as a common electrolytic solution. Powdered lead dioxide (PbO_2) A is put into the dilute sulfuric acid solution in the cathode cell 54 and suspended. Powdered metallic lead (Pb) B is put in the dilute sulfuric acid solution in the anode cell 55 and suspended.

[0136] The three-dimensional battery 41-1 according to the second embodiment as described above discharges as follows. Specifically, the cathode cell 54 in contact with the left-end cathode current collector 46 receives an electron from the current collector 46 and the electron (e^-) is fed to the powdered lead dioxide A, which is converted into lead sulfate ($PbSO_4$) and an ion is genrated according to the following formula:

$$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$$

[0137] Then, an anion in the cathode cell 54 moves through the ion-permeable separator 43 and into the cathode cell 55, where it reacts with powdered metallic lead B and discharges the electron[e^-] and the metallic lead is oxidized to be generated into powdered lead sulfate according to the following formula:

$$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$$

[0138] The electron in the anode cell 55 is collected to the current collecting member 45 and is fed from the current collecting member 45 to the powdered lead dioxide A in the cathode cell 54 on the right side, and the reaction is conducted according to the above formula to generate lead dioxide ($PbSO_4$) and the ion. The anion in the cathode cell 54 moves through the ion-permeable separator 43 into the anode cell 55, where it reacts with the powdered metallic lead B and discharges the electron and powdered lead sulfate is generated according to the above formula. The electron is collected to the current collecting member 45. This reaction is sequentially repeated in the respective unit batteries 56. The electron moves from the right-end anode current collector 47, through load means (not shown), and to the left-end cathode current collector 46. Conversely, a current flows from the cathode current collector 46, through the load means (not shown), and to the right-end current collector 47. In this example, a voltage of approximately 13.6V is generated. It should be noted that any acid-resistant conductors may be used as the current collectors or electrodes. For example, carbon or conductive polymer may be used.

(Third Embodiment)

[0139] Fig. 16 is a central longitudinal sectional view schematically showing a layered-type three-dimensional battery according to a third embodiment of the second invention.

[0140] As shown in Fig. 16, a three-dimensional battery 41-2 of this embodiment is a lead storage battery similarly to that of the second embodiment of Fig. 15. A rotational shaft 59 is rotatably provided in the battery 41-2 such that it penetrates through the battery 41-2 in the axial direction thereof, and is rotated manually or by a rotation drive device (not shown). A plurality of agitation vanes 59a are provided at positions corresponding to the cells 54, 55 on the rotational shaft 59 such that they are protruded in the direction orthogonal to the rotational shaft 59 and are adapted to agitate the dilute sulfuric solutions r and suspended powdered lead dioxide A or powdered metallic lead B in the respective cells 54, 55 by rotation of the rotational shaft. This constitution differs from that of the battery 41-1 of the second embodiment.

[0141] According to the three-dimensional battery 41-2 of this embodiment, the powdered lead dioxide A and the powdered metallic lead B as powdered electrodes are agitated to provide preferable contact between the powdered electrode A and the current collector 46, between the powdered electrode B and the current collecting members 47, or between the powdered electrodes A, B and the current collecting members 45. Therefore, a capacity of each of the cells 54, 55 (cell member 42: see Fig. 13) can be increased and a power can be correspondingly increased. In addition, since the agitation of the powdered lead dioxide A and the powdered metallic lead B as the powdered electrodes can prevent the adhesion of lead sulfate particulars to the current collectors or the current collecting members, lead plates can be employed as the current collectors 46, 47 and the current collecting members 45. Since the battery 41-2 is identical to the battery 41-1 of the second embodiment except the agitating means 59, the corresponding parts are referenced to by the same reference numerals and description thereof is omitted.

in the house 416. A wind power and solar light are optionally utilized, and the wind power electric generator 421, the solar battery 422 and the fixed battery 418 can be dispensed with. The installment of at least the inverter 419 is satisfactory. The power of the automobile can be used in houses by connecting the inverter 419 to the traveling-source battery 414 by means of the connector 417 or the like.

[0323] In this embodiment, only power equipment is explained. A heat energy generated in air-conditioning equipment, a radiator, or the like of the automobile or the like is utilized in the house to perform cogeneration. For example, warm air, cool air, or the like can be supplied from the air-conditioning equipment, the radiator, or the like of the automobile or the like, through a duct, and to the house, and utilized for air-conditioning in the house. The heat energy generated in air-conditioning equipment, a radiator, or the like of the automobile or the like can be utilized in a tent or cottage outside, which is irrelevant to the cogeneration.

[0324] As mentioned previously, the conventional house cogeneration equipment is costly and is unpayable if not used for a long time period. Although the state tried to pay half of the equipment cost of the solar power generation, which was economically unsuccessful, and a great deal of budget was surplus. Accordingly, by utilizing the power energy generated from the automobile or the like as transfer and transport means for the house instead of installing the conventional cogeneration equipment independently, house equipment cost can be significantly reduced and the distributed-type power generation can be developed.

[0325] In the automobile or the like in which a battery for power storage is mounted together with the device that uses the engine to activate the electric generator to generate the power, or the device that generates the power by the fuel battery, the power amount of the battery is several tens kW hr, and is sufficient as the power consumed in one house. When people go outside, they often use automobiles. In such cases, power supply is performed depending on whether or not the automobile is moving, by selectively using the traveling-source power or the fixed-type power.

[0326] For example, if 3 million yen is paid to purchase private power generation equipment, this is uneconomical in view of difference between 3 million yen and a purchasing price of the power. However, if 3 million yen is paid to purchase an automobile, this is economical because the automobile can be used as transfer and transport means as its original purpose as well as the power generation equipment.

[0327] The traveling-source battery 414 and the fixed battery 418 may be batteries of the three-dimensional structure in which powdered active materials are used on the cathode side and the anode side as shown in Figs. 1 to 12. Thus, the three-dimensional battery is preferable because, when part of or all of the degraded powdered materials is discarded, and the degraded powdered material is recovered by the recovery unit 27, and new powdered materials equivalent in amount to the discarded powdered materials are supplied to a vessel as shown in Fig. 10 according to the seventh embodiment of the first invention, charging can be started immediately.

[0328] While this embodiment has been described with regard to houses, the same is the case with offices.

(Industrial Applicability)

[0329] The present invention is constituted as described above, and is therefore suitable as a battery of a three-dimensional structure comprising powdered active materials and capable of storing a large power, and equipment or device having the battery as part of its structure, and an alkali primary battery and an alkali secondary battery of long lives in which discharge voltages are less likely to be reduced, and a locally-distributed power generation device which utilizes a power of transfer and transport means such as a power-driven two-wheeled vehicle, a power-driven three-wheeled vehicle, a battery-wheeled four-wheeled vehicle, ship, or the like.

Claims

1. A battery comprising two vessels connected with a member interposed therebetween that permits passage of an ion but does not permit passage of an electron, a powdered active material filled in one of the vessels and suspended in an electrolytic solution to discharge the electron, and a powdered active material filled in the other vessel and suspended in an electrolytic solution to absorb the electron, wherein conductive current collectors in contact with the powdered active materials are provided in the two vessels.

2. The battery according to Claim 1, wherein at least one of fluid fluidizing and dispersing means and agitating means using a liquid or a gas for fluidizing the powdered active materials in the electrolytic solutions in the two vessels are connected to the two vessels or provided in the two vessels to provide efficient contact between the powdered active materials and between the powdered active materials and the current collectors.

3. The battery according to Claim 1 or 2, wherein the current collectors in contact with the powdered active materials have a shape of one of a bar, a plate and a tube.

4. The battery according to Claim 2 or 3, wherein the current collectors in contact with the powdered active materials serve as at least one of the fluid fluidizing and dispersing means and the agitating means using the liquid or the gas for fluidizing the powdered active materials in the electrolytic solutions in the vessels.

5. The battery according to Claim 1, 2, 3, or 4, wherein heat transmitters are provided in the two vessels to keep reaction temperature in the battery constant.

6. The battery according to Claim 5, wherein the heat transmitters are one of tubular current collectors and plate-shaped current collectors in contact with the powdered active materials.

7. The battery according to Claims 1 to 6, wherein means for discharging degraded powdered active materials out of the two vessels and means for supplying the powdered active materials into the vessels are connected to the vessels.

8. The battery according to Claim 7, wherein at least one of means for recovering discharged powdered active materials and means for making up the powdered active materials is connected to the discharging means, to supply the recovered or made-up powdered active materials from the supplying means into vessels.

9. The battery according to Claim 7 or 8, wherein reaction means for charging the discharged powdered active materials by thermal reaction or chemical reaction is connected to the discharging means, to supply the charged powdered active materials from the supplying means into the vessels.

10. The battery according to any of Claims 1 to 9, wherein the powdered active material on an anode side is powdered hydrogen-occluding alloy and the powdered active material on a cathode side is powdered nickel hydroxide.

11. The battery according to any of Claims 2 to 9, wherein the powdered active material on an anode side is powdered hydrogen-occluding alloy, the gas introduced into the fluid fluidizing and dispersing means on the anode side is hydrogen, the powdered active material on a cathode side is powdered nickel hydroxide, and the gas introduced into the fluid fluidizing and dispersing means on the cathode side is oxygen or air.

12. A three-dimensional battery of a layered type comprising plural pairs of unit batteries each comprising a pair of cells connected with a member interposed therebetween that permits passage of an ion but does not permit passage of an electron, a powdered active material put in and suspended in an electrolytic solution filled in one of the cells to discharge the electron, and a powdered active material put in and suspended in an electrolytic solution filled in the other cell to absorb the electron, the plural pairs of batteries being integrally connected in series with conductive current collecting members placed so as to define separating walls of the respective cells and be in contact with the powdered active materials, wherein the cells on opposite sides are provided with current collectors that are in contact with the powdered active materials and respectively function as a cathode and an anode.

13. The three-dimensional battery according to Claim 12, wherein agitating means is provided in each of the cells to fluidize the powdered active material suspended in the electrolytic solution.

14. The three-dimensional battery according to Claim 12 or 13, wherein conductive studs are provided integrally with and protrusively from the current collecting members or the current collectors toward inside of the respective cells.

15. The three-dimensional battery according to Claim 13, wherein a function for stopping fluidization of the powdered active material to reduce amount of a power supplied from the battery is added to the agitating means .

16. The three-dimensional battery according to any of Claims 12 to 15, wherein the powdered active material that discharges the electron is hydrogen-occluding alloy, cadmium, iron, zinc or lead.

17. The three-dimensional battery according to any of Claims 12 to 15, wherein the powdered active material that absorbs the electron is nickel oxyhydroxide, lead dioxide, or manganese dioxide.

18. Equipment or device having a battery of a three-dimensional structure as part of its structure, comprising two vessels connected with a member interposed therebetween that permits passage of an ion but does not permit passage of an electron, a powdered active material filled in one of the vessels and suspended in an electrolytic solution in the one vessel to discharge the electron, and a powdered active material filled in the other vessel and

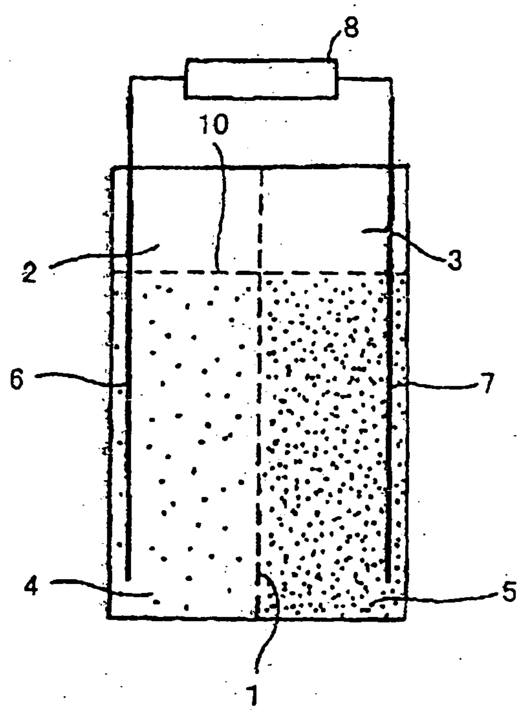

Fig. 1 (a)

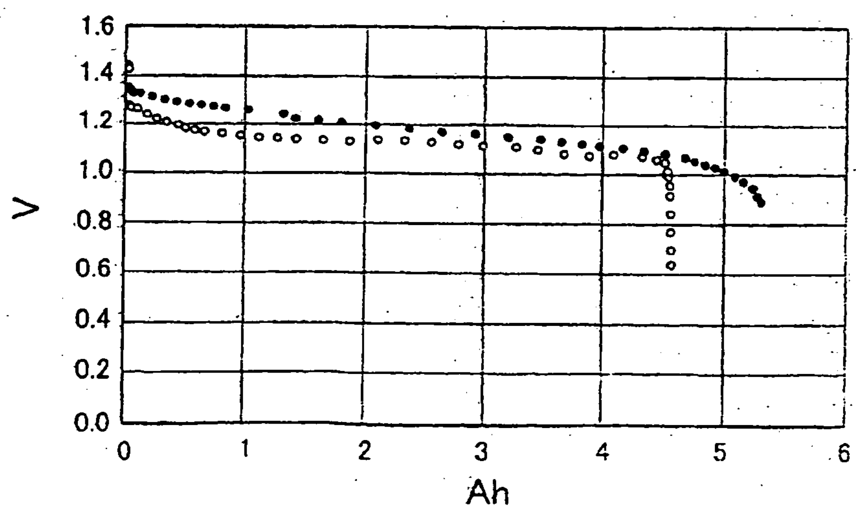

Fig. 1 (b)

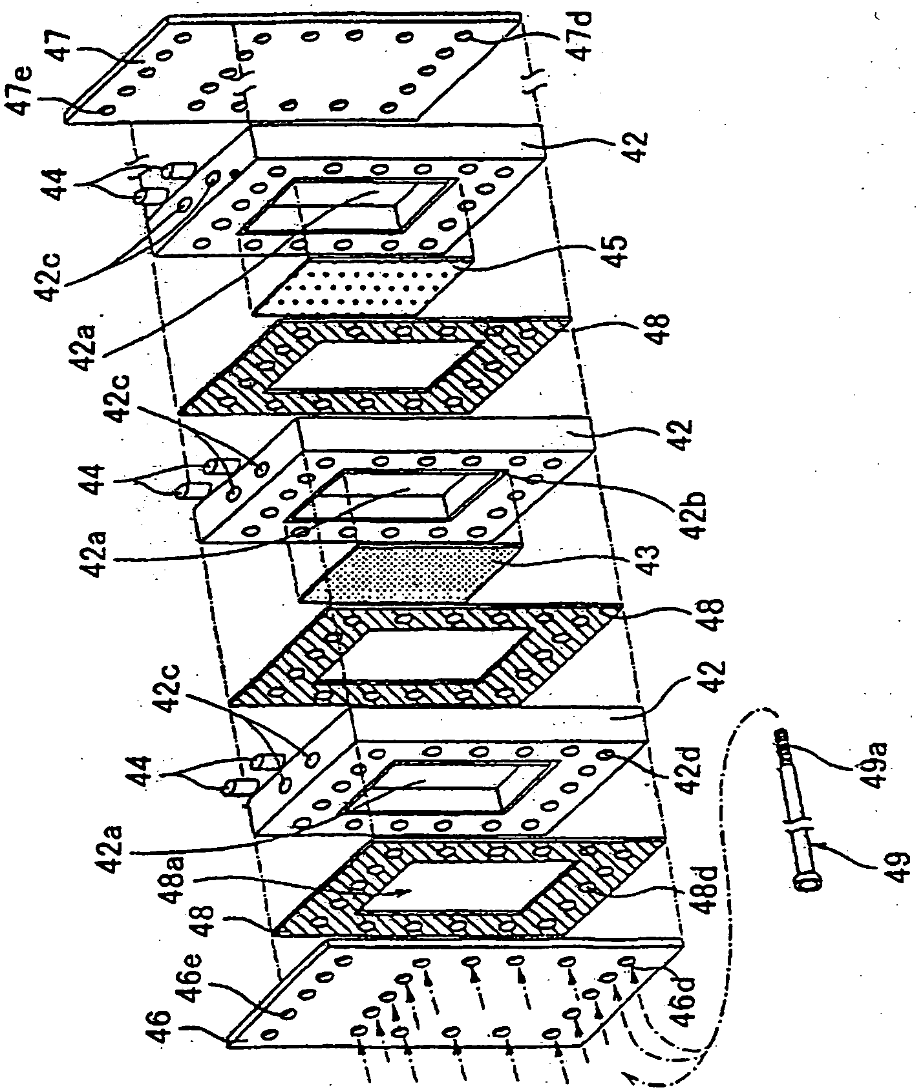
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Fig. 1 4

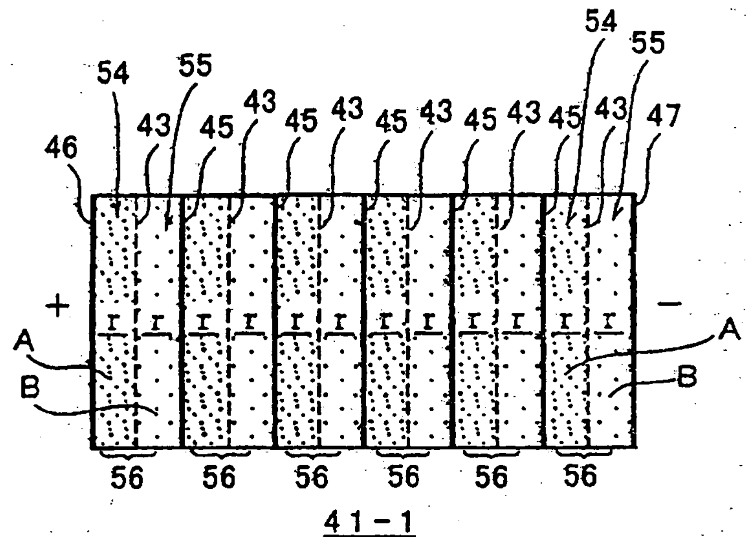
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Fig. 15

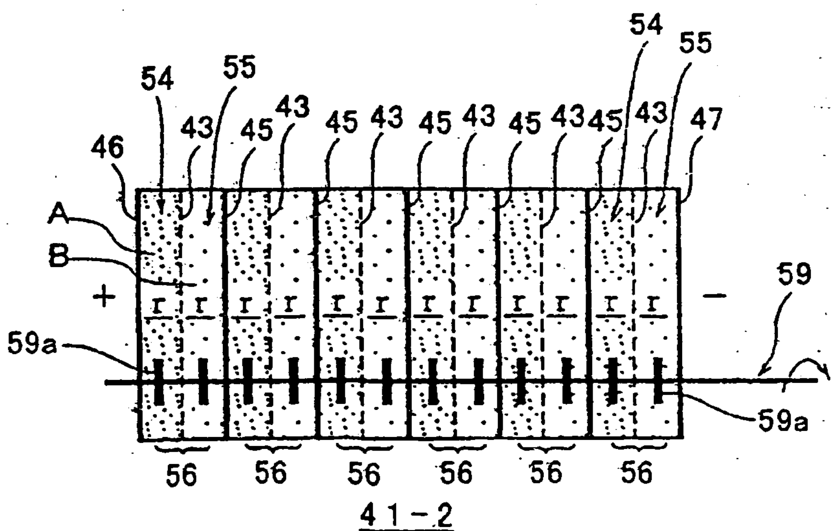
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Fig. 16

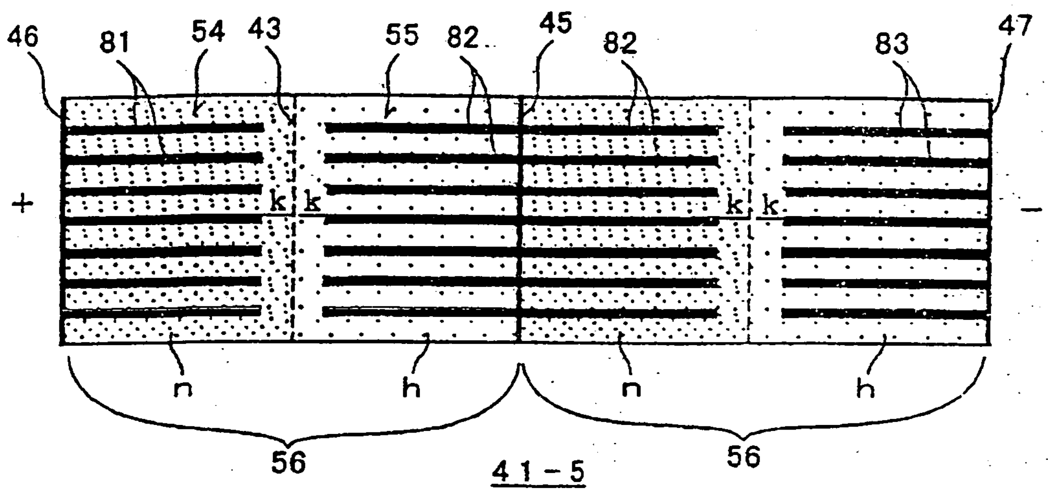

Fig. 19